



Integration of social life in a bioeconomic approach for sustainable water resource policy and management in the Brantas River

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ABSTRACT

Background: Sustainable water resource management has become a major challenge in Indonesia due to increasing pressure from domestic, agricultural, and industrial activities on river environmental quality. The Brantas River, as one of the major rivers in East Java, has experienced declining water quality characterized by high Biochemical Oxygen Demand (BOD) values, increased nutrient content, and biological contamination. These conditions are influenced not only by ecological factors but are also closely related to social behavior, community norms, and patterns of water resource utilization. This study aims to analyze the relationship between community social life and the ecological condition of the Brantas River through a bioeconomic approach and to identify the role of community participation in supporting sustainable water resource management. **Methods:** The study employs a descriptive qualitative approach based on a systematic literature review (SLR) using data obtained from scientific articles, government reports, and policy documents related to the Brantas River. The analysis was conducted thematically by integrating social and biophysical variables within the framework of bioeconomics and Social Ecological Systems (SES). **Findings:** The results indicate that the degradation of Brantas River water quality is influenced by the interaction between community economic activities, social behavior, and the ecological capacity of the river. Low environmental awareness, domestic waste disposal practices, and weak environmental management are the main factors contributing to increased pollution, while community participation and community-based monitoring positively contribute to river conservation efforts. **Conclusion:** This study concludes that the sustainability of Brantas River management depends not only on technical approaches but also on strengthening social governance, community participation, and the integration of bioeconomics into water resource management. **Novelty/Originality of this article:** The novelty of this research lies in its integrative approach that connects water quality indicators, economic activities, and social variables within a single socio-bioeconomic analytical framework to support more sustainable river management.

KEYWORDS: Brantas River; community participation; environment; social life; sustainability.

1. Introduction

Sustainable water resource management is an important issue in Indonesia, particularly in river basin areas facing social, economic, and environmental pressures. The Brantas River, the second-longest river on Java Island, serves as a source of raw water, irrigation water for agriculture, industrial water supply, and daily water needs for hundreds of thousands of residents in East Java (Hariwati et al., 2026). However, pressure from domestic, agricultural, and industrial human activities has caused water pollution and

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increased environmental degradation. Water quality analysis in several areas of the Brantas River shows varying conditions (Rizky & Rahayu, 2025). Parameters such as biological oxygen demand (BOD) often exceed established standards, especially in the middle to downstream sections of the river (Irawanto et al., 2024). Managing biological resources requires balancing ecological limits and economic benefits. Management failures often occur due to the separation between biological data and social dynamics (Pascucci, 2025).

Other studies have also identified pollution potential caused by agricultural activities and seasonal changes in the Brantas Watershed, particularly at 142 sampling points across five sub-catchment areas. The results indicate a significant relationship between the intensity of agricultural activities and increased pollutant parameters in the river during both dry and rainy seasons (Sipahutar et al., 2025). In addition, community-based studies involving local groups in water quality monitoring reported parameters such as pH (± 7.4), dissolved oxygen (DO) (± 6 mg/L), and relatively high BOD values (13.83 mg/L). These conditions are influenced not only by economic activities and seasonal changes but also by social norms, community behavior, and low participation in protecting the river environment, with coliform indicators showing significant biological contamination (Sulistiyowati & Uyun, 2022). Thus, pollution in the Brantas River is the result of interactions between ecological pressures and community social practices (Fitriyah et al., 2026).

These conditions have direct implications for communities living along the riverbanks. Sociological studies show that some families still use Brantas River water for domestic needs despite its polluted condition, and some children suffer from health problems such as diarrhea and skin diseases related to exposure to contaminated water. These findings highlight community health vulnerability and the need for community-based interventions in water resource management (Budirahayu et al., 2024).

Furthermore, effective river management depends on riparian vegetation conditions and proper household waste management. Riparian vegetation plays a critical role in maintaining river ecosystem balance, preventing erosion, and improving water quality (Ali et al., 2024). This socio-bioeconomic approach positions communities as the main actors in maintaining balance between the economic and ecological functions of the river. Strengthening collective norms related to waste management, increasing environmental literacy, and implementing community-based monitoring systems can enhance the social-ecological resilience of the watershed (Pambudi et al., 2023). Collaboration among local governments, academics, the private sector, and local communities is a prerequisite for creating adaptive governance responsive to seasonal changes, social dynamics, and development pressures. Integrating social, environmental, and economic aspects in watershed management requires cooperation among governments, communities, and other stakeholders to create inclusive and adaptive management systems (Sulistiyowati & Uyun, 2022).

Therefore, integrating social life into a bioeconomic approach is an important strategy for supporting sustainable Brantas River management. This approach positions communities as the primary actors in maintaining balance between economic utilization and ecosystem conservation (de Souza & Cândido, 2024). Community-based, participatory, and adaptive policies are expected to strengthen the river's social-ecological resilience and serve as a model for managing other river basins in Indonesia (Ali et al., 2024).

1.1 The Brantas river as a social-ecological system

The Brantas River is more than a channel that carries water from upstream to downstream. It is a social-ecological system in which ecological processes and human activities continuously interact with and influence one another. The river provides water for domestic needs, irrigation, fisheries, industry, and other activities. At the same time, these activities can introduce nutrients, organic matter, solid waste, heavy metals, and other contaminants into the aquatic environment. This dual role creates a management challenge because decisions that provide short-term social or economic benefits may also generate

environmental costs that emerge later or are experienced by other users. Therefore, sustainable management needs to view the river as an interconnected system rather than addressing each pollution source or user group in isolation (Gowsikraja, 2025).

Previous studies reviewed in this study indicate that the environmental condition of the Brantas River varies across both space and time. Changes in water quality from upstream to downstream have been reported, including elevated BOD at several locations and declining dissolved oxygen (DO) levels (Irawanto et al., 2024). Agricultural activities and seasonal conditions have also been associated with changes in nutrient and pollution parameters across the watershed (Sipahutar et al., 2025). These studies provide an important foundation for the present review because they demonstrate that environmental pressures are not evenly distributed. The condition of a particular river segment reflects a combination of activities occurring upstream, local land use, hydrological conditions, and the river system's capacity to process or transport pollutants (Sidjabat et al., 2020).

1.2 Water quality as an indicator of ecological pressure

Water-quality parameters provide a practical means of describing river conditions and identifying environmental pressures associated with human activities. BOD reflects the amount of oxygen required to break down biodegradable organic matter, while DO indicates the amount of oxygen available to aquatic organisms. Nitrate and phosphate are important indicators of nutrient inputs and may increase as a result of agricultural runoff and other anthropogenic sources. Chemical oxygen demand (COD) indicates the amount of oxygen required to chemically oxidize substances in the water. When considered together, these parameters provide a more comprehensive picture of the environmental pressures affecting the river (Mahira et al., 2026).

The secondary evidence summarized in the original manuscript indicates that seasonal variation is an important factor. The values adapted from the reviewed study show higher nitrate, phosphate, BOD, and COD levels during the rainy season, accompanied by lower DO levels. Rather than viewing these values simply as a collection of laboratory measurements, the pattern can be understood in relation to processes occurring across the watershed. Rainfall can mobilize materials from agricultural land, settlements, and other surfaces and carry them into river channels. As a result, pollution pressures may change with the season even when the underlying economic activities remain relatively similar. This is particularly relevant for management because a monitoring program based on a single sampling period may not capture the full range of environmental conditions (Sipahutar et al., 2025).

The spatial dimension is equally important. The reviewed studies indicate stronger pollution pressures in several middle and downstream areas, where population density, settlements, agricultural activities, and industrial activities are more concentrated. Upstream areas, by contrast, may have different environmental characteristics due to land cover, riparian vegetation, and lower concentrations of certain human activities. This spatial variation suggests that management interventions do not necessarily need to be identical across the entire watershed. A local pollution problem may require a different response from a watershed-scale pressure, while prevention in upstream areas can play an important role in reducing environmental loads downstream (Pambudi et al., 2023).

The literature also shows that environmental assessment of the Brantas River is becoming increasingly comprehensive. Earlier studies often focused on conventional parameters such as BOD, COD, DO, nitrate, phosphate, and pH. More recent studies have expanded the scope to include heavy metals, microplastics, and biological responses. Heavy-metal contamination and biological responses in wild Cyprinidae have been examined as indicators of environmental pressure in the river system (Islamy et al., 2025). The distribution of microplastics has also been investigated in relation to water-quality parameters from the upstream to the downstream sections of the river (Rina et al., 2026). Pb and Cd contamination has further been assessed using physiological responses in *Oreochromis niloticus* (Islamy et al., 2025). Taken together, these studies suggest that river degradation cannot be adequately represented by a single indicator. Chemical, physical,

particulate, and biological evidence need to be considered together when assessing ecological capacity (Estoque et al., 2026).

1.3 Microplastics as a new dimension of brantas river pollution

The inclusion of recent evidence on microplastic pollution adds an important dimension to the literature reviewed in this study. The spatial distribution of microplastics from upstream to downstream has been examined in relation to water-quality parameters in the Brantas River. The reported concentration increased from 6.90 particles/L in the upstream area to 26.29 particles/L downstream (Rina et al., 2026). The study also identified relationships between microplastic concentrations and BOD, COD, temperature, total suspended solid (TSS), DO, nitrate, phosphate, and flow velocity. This evidence is valuable because it connects an emerging pollutant with the conventional water-quality indicators already discussed in the Brantas River literature.

Microplastics are particularly relevant to a socio-economic analysis because their presence is closely linked to patterns of production, consumption, waste generation, and waste management. Plastic materials provide economic and practical benefits in everyday life, but poorly managed plastic waste can enter aquatic systems and persist for long periods. Once transported by rivers, small plastic particles can be distributed across water, sediment, and aquatic organisms. As a result, the environmental costs may extend beyond the location where the waste was originally generated. This characteristic makes microplastic pollution relevant to the concept of external environmental costs within a bioeconomic framework (Kurniawan et al., 2025).

The findings also highlight the importance of avoiding an overly narrow interpretation of water quality. Increasing microplastic concentrations downstream and their relationships with BOD, COD, TSS, and DO indicate that conventional water-quality assessments alone may not fully capture the overall pollution profile (Rina et al., 2026). Within the proposed framework, microplastics can therefore be considered an additional indicator of ecological pressure. They do not replace BOD, DO, nutrients, or other parameters; rather, they complement these indicators. This broader perspective is consistent with the objective of the present systematic literature review (SLR), which is to connect different forms of ecological evidence instead of focusing on a single type of pollutant.

From a management perspective, the evidence on microplastics also points to the importance of reducing pollution at its source and strengthening waste-management systems. River clean-up activities can remove visible waste, but they do not necessarily prevent new plastic inputs. A more integrated approach should connect household waste practices, waste-collection infrastructure, public awareness, industrial practices, and environmental monitoring. In this way, microplastic management can become part of a broader socio-ecological strategy rather than being treated as an isolated technical intervention (Rifai et al., 2026).

1.4 Heavy metals and biological responses

Heavy-metal contamination is another environmental pressure that deserves attention because metals can persist in aquatic environments and accumulate in organisms. Contamination by Pb, Cd, Hg, Cu, and Zn, along with associated biological responses, has been reported in wild Cyprinidae (Islamy et al., 2025). More recent evidence has examined Pb and Cd contamination using *Oreochromis niloticus* as a biomonitoring organism. The study also reported increasing accumulation toward downstream stations and described physiological and histopathological responses (Islamy et al., 2025). These findings extend the analysis beyond the presence of contaminants to their potential biological consequences (Sidjabat et al., 2020).

Biological responses are important within the proposed framework because ecological conditions cannot always be understood from water chemistry alone. A river may show

changes in pollutant concentrations that are difficult to interpret without information on exposure and biological responses. Hematological and histopathological indicators can provide additional evidence that organisms are experiencing physiological stress. In the context of this SLR, these findings are not treated as new measurements. Instead, they represent evidence generated by previous researchers that can be incorporated into the ecological-response component of the proposed framework.

1.5 Economic activities and environmental trade-offs

The downstream patterns reported in the heavy-metal literature are also consistent with the broader spatial perspective developed in this study. Downstream areas receive materials transported from upstream as well as additional inputs from local activities. However, downstream conditions should not automatically be attributed to a single source because multiple processes may occur simultaneously. Therefore, the SLR treats upstream-to-downstream patterns as evidence of spatial differentiation and uses the cited studies to identify possible environmental pressures rather than claiming a single causal pathway without direct quantitative testing.

The Brantas River supports a wide range of economic activities that are important to local communities and regional development. Agriculture depends on water for irrigation, households rely on the river system for various domestic needs, fisheries depend on aquatic habitats, and industrial activities require water as an important input. These activities should not be viewed solely as sources of pollution. They also represent legitimate social and economic needs. The bioeconomic perspective is valuable precisely because it considers how these benefits can be maintained while reducing the environmental costs associated with resource use (Gowsikraja, 2025).

Environmental degradation can generate costs that are not always reflected in the immediate economic calculations associated with resource use. For example, pollution can increase the cost of obtaining clean water, reduce the suitability of aquatic habitats, affect fisheries, increase exposure risks, or require additional investment in treatment and ecosystem restoration. These costs may ultimately be borne by households, governments, businesses, or future users rather than by the activities that generated the initial environmental pressure. This is one reason environmental management needs to consider externalities and long-term ecological consequences alongside short-term economic benefits (Ba & Galik, 2022).

1.6 Community behavior, vulnerability, and participation

In the Brantas context, a bioeconomic interpretation does not simply mean assigning a monetary value to every environmental parameter. Rather, it means recognizing the relationship between resource use and ecological limits and examining how management decisions affect both human well-being and ecosystem conditions. The framework proposed in this study can therefore be used to organize evidence on where economic activities generate environmental pressures, how the river responds to those pressures, who experiences the consequences, and which governance mechanisms may help reduce them (de Souza & Cândido, 2024).

2. Methods

Sustainable water resource management requires a multidisciplinary approach integrating ecological, economic, social, and public policy dimensions. The Brantas River, as one of the major rivers in East Java, plays an important role in meeting irrigation, domestic consumption, industrial, and local ecosystem needs. Human activities such as agriculture, domestic waste disposal, and industrial operations place significant pressure on river water quality, which in turn threatens the welfare of communities dependent on the river and the sustainability of its ecosystem (Sipahutar et al., 2025).

In this study, bioeconomics is understood not only as an economy based on biological resources but also as a framework connecting community economic activities with the ecological capacity of the Brantas River through governance systems and social participation. Through bioeconomics, river management strategies are formulated by considering ecological limits, economic potential, and social needs. For example, bioeconomic models are used to analyze how river water utilization, agricultural activities, and domestic waste influence water quality, resource stocks, and economic outcomes, enabling management strategies that minimize ecosystem degradation while maximizing socio-economic benefits (Sipahutar et al., 2025). Thus, the sustainability of river management is determined not only by economic efficiency but also by interactions among social behavior, ecological capacity, and governance mechanisms (Ramcilovic-Suominen, 2023).

Research methods include water sampling at multiple points along the Brantas Watershed during two seasonal periods. Water quality parameters analyzed include common physical and chemical indicators used to detect pollution from agricultural runoff, such as nutrient content (nitrate and phosphate) (Sipahutar et al., 2025). A qualitative approach was conducted through in-depth interviews and observations involving women living near the Brantas River. Sociological and gender perspectives were used to examine the relationship between knowledge, environmental awareness, socio economic conditions, and health vulnerability (Budirahayu et al., 2024). The concept of governance in this study functions as a mechanism bridging the relationship between socio-economic activities and the ecological sustainability of the Brantas River.

The study also examines riparian vegetation, namely plant communities living along riverbanks, including trees, saplings, and seedlings that play important roles in maintaining river ecosystem stability through functions such as erosion control, nutrient absorption, and habitat provision (Ali et al., 2024). Brantas River water quality declines from upstream to downstream due to domestic, agricultural, and industrial activities. Parameters such as BOD, nitrate, phosphate, and dissolved oxygen indicate increasing pollution along the river flow (Irawanto et al., 2024). Agricultural activities directly increase nutrient content, particularly during the rainy season. Bioeconomic management must therefore consider spatial and seasonal variations in water quality to support appropriate mitigation strategies (Sipahutar et al., 2025).

Community involvement through digital technology in river water quality monitoring is also highlighted. Participatory websites enable communities to upload real-time water quality data, strengthening social and participatory dimensions of river management. The integration of participatory data with scientific monitoring can improve policy effectiveness, transparency, and accountability in bioeconomic management while empowering local communities (Sulistiyowati & Uyun, 2022). The sustainability of the Brantas Watershed depends not only on regulations from central government but also on institutional strengthening at the meso level. This meso-institutional perspective supports participatory digital platforms and social groups, such as women's communities, as connectors between macro-level government policies and local social-environmental needs. In a polycentric system, duplicated data from government sensors and community reports actually increases resilience to pollution and disasters, creating more responsive social control mechanisms against seasonal and economic changes (Pascucci, 2025).

The research gap identified in this review is therefore an integration gap. The existing literature already contains valuable empirical information about water quality, agricultural pressure, heavy metals, microplastics, community vulnerability, participation, and governance. What is less developed is an analytical structure that places these evidence streams into one connected socio-bioeconomic system. The present study contributes by synthesizing the studies and defining how their variables can be related. This contribution should be understood as a framework-building and evidence-synthesis contribution, not as a claim that the systematic literature review (SLR) itself estimates new causal relationships (Holmes et al., 2025).

Adaptive governance provides a way to connect monitoring and decision-making through feedback. Monitoring identifies changes in ecological condition; the information can then be communicated to communities and institutions; management measures can be adjusted; and the effects of those measures can be evaluated through subsequent monitoring. This cycle is particularly relevant to a river system with seasonal and spatial variation. The purpose is not to create a fixed management response for all situations, but to create a process through which evidence can be used to adjust decisions (World Meteorological Organization, 2021).

Water-resource management is characterized by uncertainty because environmental conditions, human activities, and institutional responses change over time. In this context, effective water governance requires the capacity to respond to complex management challenges and changing environmental and social conditions (Pahl-Wostl et al., 2020). Coordination among actors and institutions at different governance levels is also important within a polycentric governance system (Pahl-Wostl & Knieper, 2023). These perspectives are particularly relevant to the Brantas River because its management involves multiple actors with different responsibilities, interests, and sources of information. Government agencies, local communities, industries, academic institutions, and other organizations may therefore contribute differently to environmental management and the sustainable use of water resources.

3. Results and Discussion

3.1 Water resource management from a systems perspective

Water resource management is a system involving interactions among ecological, economic, and social aspects. In the Brantas River, increasing pollution levels, such as high Biological Oxygen Demand (BOD), nitrate, and phosphate concentrations, are influenced by domestic, agricultural, and industrial activities (Sipahutar et al., 2025). Based on secondary data from 142 observation points within the Brantas Watershed, BOD values in several river segments reached approximately ± 13.83 mg/L, exceeding the Class II water quality standard of 3 mg/L.

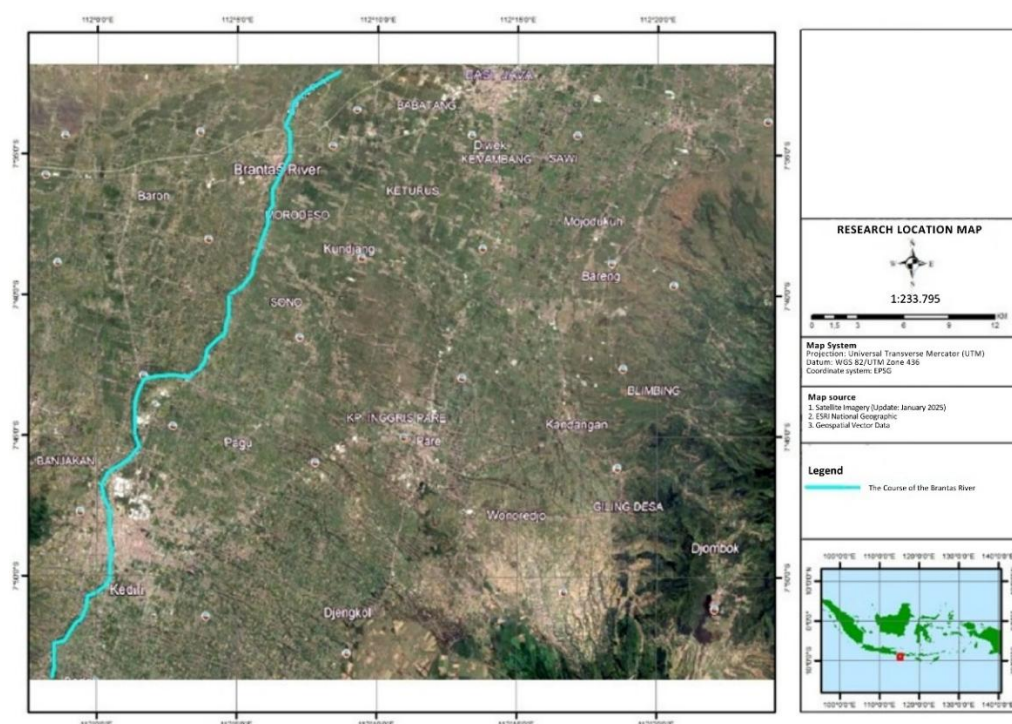


Fig. 1. Location of the Brantas watershed

In addition, dissolved oxygen (DO) levels decreased at several observation locations, indicating a declining capacity of the river to support aquatic organisms (Irawanto et al., 2024). The Brantas Watershed covers approximately 11,800 km² and is one of the most important river systems in East Java, supporting domestic water supply, irrigation, fisheries, and industrial activities (Rizky & Rahayu, 2025). The research data were obtained through a Systematic Literature Review (SLR) approach using scientific articles, government reports, and policy documents related to the Brantas River. Therefore, this study did not directly involve field respondents, but instead used social analysis units derived from previous studies. Respondents in earlier studies generally consisted of communities living along the Brantas River, household groups, environmental communities, farmers, and domestic activity actors directly interacting with water resources (Budirahayu et al., 2024). Most previous studies have primarily focused on the technical aspects of water quality and pollution sources, with limited integration of biophysical indicators, community economic activities, and social behavior within a socio-bioeconomic analytical framework (Cahyani & Irawanto, 2022).

Most previous studies have primarily focused on the technical aspects of water quality and pollution sources, with limited integration of biophysical indicators, community economic activities, and social behavior within a socio-bioeconomic analytical framework (Pambudi et al., 2023). Earlier research mainly emphasized water quality parameters such as BOD, DO, pH, nitrate, and phosphate concentrations without operationally explaining the relationship between community participation, collective norms, and river ecological capacity (Pahl-Wostl et al., 2020). Therefore, this study attempts to integrate ecological indicators, economic utilization, and social variables within the framework of bioeconomics and Social Ecological Systems (SES) to provide a more comprehensive understanding of sustainable river management (Barbier, 2022).

3.1.1 Bioeconomics

The bioeconomic approach emphasizes that economic activities must remain within the ecological carrying and assimilative capacities of the environment in order to maintain long-term sustainability (Barbier, 2022). In the context of the Brantas River, agricultural activities, chemical fertilizer use, domestic waste disposal, and industrial activities exert significant pressure on river water quality (Aranceta-Garza et al., 2025). Secondary data from previous studies indicate that increasing domestic and agricultural activities are positively correlated with rising concentrations of organic matter, nitrate, and phosphate within the river body (Sipahutar et al., 2025). In several downstream segments of the river, increased nutrient accumulation has contributed to higher Biological Oxygen Demand (BOD) values and declining dissolved oxygen (DO) levels, indicating ecological stress within the aquatic system (Irawanto et al., 2024).

The Brantas River supports various economic sectors, including irrigation, fisheries, household water use, and industrial production. However, the increasing intensity of resource utilization has exceeded the ecological capacity in several densely populated areas. According to Statistics Indonesia in 2025, population growth and urban expansion along the Brantas River have increased domestic wastewater production and solid waste disposal into the river system (Gholizadeh et al., 2021). Comparatively, upstream regions generally maintain better water quality conditions due to lower population density and stronger riparian vegetation coverage, while middle and downstream regions experience higher pollution loads because of concentrated settlements, agricultural intensification, and industrial activities (Ali et al., 2024).

In previous studies used as secondary data sources for this research, social respondents generally consisted of riparian communities, farmer groups, household users, women groups, and environmental communities directly interacting with river resources (Budirahayu et al., 2024). Many communities still relied on river water for bathing, washing, and other domestic activities despite declining water quality conditions. Some households continued disposing domestic waste directly into the river due to limited waste

management facilities, inadequate sanitation infrastructure, and low environmental awareness (Budirahayu et al., 2024). These conditions indicate that economic activities and community social behavior are directly associated with river ecological degradation.

From a bioeconomic perspective, environmental degradation occurs when short-term economic benefits are prioritized over long-term ecological sustainability (Barbier, 2022). Excessive exploitation and pollution reduce the river's carrying and assimilative capacities, ultimately threatening ecosystem resilience and community welfare (Purwanto et al., 2023). Therefore, sustainable river management requires balancing economic utilization with ecological preservation through adaptive governance, community participation, and integrated environmental management approaches (Pahl-Wostl & Knieper, 2023).

Table 1. Variation of water quality parameters in the brantas watershed

Parameter	Unit	Dry Season	Rainy Season	Interpretation
Nitrate (NO_3^-)	mg/L	4.5	7.8	Increased during the rainy season due to agricultural runoff.
Phosphate (PO_4^{3-})	mg/L	0.12	0.25	Higher concentrations indicate increased nutrient loading.
Dissolved Oxygen (DO)	mg/L	6.2	5.4	Lower DO during the rainy season suggests higher organic pollution.
Biological Oxygen Demand (BOD)	mg/L	2.8	4.6	Increased BOD reflects higher organic matter inputs.
Chemical Oxygen Demand (COD)	mg/L	12.5	21.3	Elevated COD indicates greater pollutant loads during the rainy season.

(Sipahutar et al., 2025)

3.1.2 Economic utilization and ecological carrying capacity

The sustainability of river management depends on the ecological carrying and assimilative capacities of the environment (Barbier, 2022). In the Brantas Watershed, increasing agricultural, domestic, and industrial activities have contributed to rising Biological Oxygen Demand (BOD), nitrate, and phosphate concentrations, particularly in the middle and downstream areas (Sipahutar et al., 2025). At several monitoring points, BOD values reached ± 13.83 mg/L, exceeding the Class II water quality standard of 3 mg/L, while dissolved oxygen (DO) levels declined due to increasing organic pollution (Irawanto et al., 2024).

In addition to nutrient and organic pollution, heavy metal contamination has become an emerging environmental issue in the Brantas River. Islamy et al. (2025) reported increasing concentrations of lead (Pb), cadmium (Cd), mercury (Hg), copper (Cu), and zinc (Zn) from upstream to downstream sections of the river. The study also revealed elevated micronucleus frequencies and gill histopathological damage in wild Cyprinidae, indicating genotoxic and physiological stress caused by prolonged exposure to aquatic pollutants. These findings suggest that deteriorating water quality not only affects physicochemical conditions but also threatens aquatic biodiversity and ecosystem health (Islamy et al., 2025).

Table 2. Summary of water quality indicators and environmental pressures in the brantas river

Study	Parameter	Main Findings
Sipahutar et al. (2025)	BOD, nitrate, phosphate	Agricultural activities and seasonal variation influenced pollution levels in the Brantas Watershed.
Irawanto et al. (2024)	BOD, DO	BOD reached ± 13.83 mg/L and exceeded the Class II water quality standard.
Islamy et al. (2025)	Pb, Cd, Hg, Cu, Zn	Heavy metal accumulation increased from upstream to downstream sections of the river.
Kurniawan et al. (2025)	Microplastics, heavy metals	Microplastics acted as carriers of heavy metals and indicated water quality degradation.

Social data from previous studies showed that some respondents living along the Brantas River still used river water for washing, bathing, irrigation, and disposing of household waste directly into the river because of limited sanitation facilities (Budirahayu et al., 2024). Respondents generally included riparian communities, household groups, farmers, and women communities directly interacting with river resources (Aggarwal & Anderies, 2023). From a bioeconomic perspective, these conditions indicate an imbalance between economic utilization and ecological capacity. Excessive resource use and pollution have reduced the river's ability to naturally recover, threatening environmental sustainability and community welfare (Pahl-Wostl & Knieper, 2023).

3.1.3 Bioeconomics as an analytical framework

This study uses bioeconomics as an analytical framework to: identify the relationship between community economic activities and changes in the water quality of the Brantas River. Assess resource utilization based on the carrying and assimilative capacities of the environment. Analyze short-term economic impacts and long-term ecological risks. Formulate Brantas River management based on bioeconomics and Social Ecological Systems (SES). The analyzed data consist of biophysical variables such as BOD, DO, pH, nitrate, and phosphate, as well as social data including community behavior, participation levels, social norms, and economic activities of riverside communities (Nugroho, 2025).

3.2 Social ecological systems (SES)

The Social Ecological Systems (SES) approach emphasizes that environmental sustainability is influenced by interactions among humans, natural resources, and governance systems (Pahl-Wostl et al., 2020). In the context of the Brantas River, respondents from previous studies indicated that many communities still use river water for bathing, washing, irrigation, and other domestic purposes despite declining water quality conditions (Budirahayu et al., 2024). Several studies also reported community participation in mutual cooperation activities, participatory water quality monitoring, and community-based environmental management programs (Sulistiyowati & Uyun, 2022).

However, the level of participation varies across regions and is influenced by education level, institutional support, environmental awareness, and access to environmental information (Aggarwal & Anderies, 2023). Communities in areas with stronger institutional support generally show higher participation in river conservation activities compared to areas with limited environmental programs. These conditions indicate that water quality degradation is influenced not only by ecological pressures, but also by social norms, collective behavior, and environmental governance systems (Bourceret et al., 2022). Therefore, sustainable management of the Brantas River requires integration between ecological management, community participation, and adaptive governance approaches (Sulistiyowati & Uyun, 2022).

3.3 Environmental governance and adaptive governance

The adaptive governance approach emphasizes the importance of flexible, participatory, and social learning-based governance in water resource management (Pahl-Wostl et al., 2020). Social data from previous studies indicate that communities involved in community-based water quality monitoring programs demonstrate higher levels of environmental awareness and participation compared to communities not involved in such programs (Sulistiyowati & Uyun, 2022). Respondents in previous studies generally consisted of riparian communities, household groups, local environmental organizations, and women communities directly interacting with the Brantas River.

In addition, several local communities have begun using digital-based reporting and participatory water quality monitoring systems as innovations in environmental governance (Sulistiyowati & Uyun, 2022). Communities with stronger institutional support

and access to environmental information tend to show better participation in river conservation activities (Aggarwal & Anderies, 2023). A collaborative and polycentric governance system enables coordination among governments, communities, industries, and other sectors in maintaining the sustainability of the Brantas (Pascucci, 2025). Therefore, adaptive governance is considered important for improving environmental management capacity and strengthening socio ecological resilience in the Brantas Watershed.

3.4 Integrated interpretation of the evidence

The literature synthesis suggests that the Brantas River should be understood and managed as an interconnected system. Evidence on BOD, DO, nitrate, phosphate, COD, microplastics, and heavy metals reflects different dimensions of ecological pressure, while social studies provide insights into how communities use the river and participate in its management. When these findings are considered together, the issue is not simply the presence of individual pollutants. Rather, it involves the interaction between resource use, pollutant generation, ecological responses, social vulnerability, and institutional capacity.

The upstream–downstream perspective is particularly important for bringing these different sources of evidence together. Pollution generated in one part of the watershed may be transported and transformed before reaching other sections of the river (Irawanto et al., 2024). At the same time, downstream areas may receive additional inputs from settlements, agricultural activities, and industry (Sipahutar et al., 2025). The spatial distribution of microplastics from upstream to downstream provides evidence of this spatial pattern and illustrates the importance of considering changes in pollution conditions along the river system (Rina et al., 2026). Studies examining heavy metals and conventional water-quality parameters provide complementary evidence for understanding these environmental pressures (Islamy et al., 2025). Taken together, the literature supports a management perspective that recognizes the connections between locations rather than treating each monitoring station as an isolated point (Sidjabat et al., 2020).

Seasonal variation adds another important dimension to this system. The water-quality evidence summarized from the reviewed study shows differences between the dry and rainy seasons, particularly in nutrient levels and indicators of organic pollution (Sipahutar et al., 2025). Seasonal conditions can influence pollutant transport, dilution processes, and biological responses. From a management perspective, this suggests that the frequency and timing of monitoring and interventions may affect how effectively environmental problems are identified. A monitoring system based only on annual averages may overlook periods when environmental pressures are considerably higher (Sipahutar et al., 2025).

3.5 Operationalization of the bioeconomic framework

To make the proposed framework analytically useful, its components can be organized into four groups of variables: pressure, response, welfare, and governance. Economic and household activities form the pressure component, including agricultural intensity, domestic water use, industrial activities, and waste generation. Ecological conditions are represented by water-quality indicators and emerging contaminants. Biological responses provide evidence of effects on aquatic organisms. Social variables capture community behavior, vulnerability, environmental awareness, and participation, while governance variables reflect monitoring activities, institutional coordination, information exchange, and management responses.

The framework can be understood as a feedback relationship. Economic and household activities generate environmental pressures; these pressures alter ecological conditions; ecological changes affect ecosystem services and human well-being; social experiences and environmental information influence behavior and participation; governance arrangements shape collective responses; and management interventions, in turn, influence resource use and environmental pressures. This formulation makes the framework more

than a narrative description because each component can be linked to measurable indicators that can be examined through future empirical research.

For example, agricultural activity can be represented by land-use indicators or measures of activity intensity, while environmental pressure can be assessed through nutrient concentrations. Ecological responses can be represented by BOD and DO, whereas emerging pollution can be assessed using microplastic and heavy-metal measurements. Social behavior may be represented by waste-disposal practices or patterns of river-water use, while participation can be assessed through involvement in monitoring or conservation activities. Governance can be represented by the availability and effectiveness of reporting, coordination, and monitoring mechanisms. These indicators could subsequently be analyzed quantitatively using primary data.

The SLR conducted in this study does not claim that all of these relationships have been statistically demonstrated using a single dataset. Instead, the operationalization of the framework is intended to show how evidence from different studies can be connected and to identify relationships that require further empirical testing. This distinction is important because the available literature differs in sampling locations, study periods, indicators, and research designs. A pooled statistical model would require comparable datasets, which are not available in the present review.

3.6 Implications for environmental management

The integrated evidence suggests that environmental monitoring should move toward a multi-indicator approach. Conventional parameters remain essential, but microplastics, heavy metals, and biological responses can provide additional information about ecological stress. Monitoring should also retain spatial and seasonal dimensions because the reviewed studies indicate that environmental conditions vary across locations and periods. This does not mean that every monitoring program needs to measure every possible parameter. Rather, indicators should be selected according to the environmental pressures and management questions relevant to each river segment (Kurniawan et al., 2025).

Waste and sanitation management should also be more closely connected with environmental monitoring. Where communities depend on the river and waste-management facilities remain limited, pollution control requires more than public awareness campaigns alone. Infrastructure, service availability, local institutions, and community participation need to function together. The social evidence reviewed in this study supports this interpretation because community behavior occurs within a broader system shaped by access, social norms, information, and institutional support (Mahira et al., 2026).

The findings also support strengthening participatory monitoring. Community observations can provide valuable information at the local level while increasing awareness of environmental conditions. However, participatory monitoring should be connected to scientific and governmental monitoring systems so that community observations can be validated and translated into appropriate management responses. In this context, participation becomes part of a broader environmental information system rather than functioning as a stand-alone community activity.

For economic activities, management should aim to reduce environmental costs while maintaining socially important uses of the river. Agriculture, industry, fisheries, and domestic water use cannot simply be eliminated because they provide essential benefits to communities. Instead, a bioeconomic perspective encourages greater attention to efficiency, pollution prevention, resource-use limits, and the long-term value of ecological functions. Such an approach can help decision-makers identify situations in which prevention may be more efficient than responding to environmental damage after it has accumulated (Kisam & Yustiana, 2025).

3.7 Clarification of the study's novelty

The novelty of this study lies in the development of an integrative bioeconomic framework that connects water quality indicators, community economic activities, and social variables such as participation, environmental awareness, and collective norms within a single analytical model (Barbier, 2022). Unlike previous studies that mainly focused on technical water quality analysis, this research integrates ecological, economic, and social dimensions through the Social Ecological Systems (SES) approach (Pahl-Wostl et al., 2020). This study combines biophysical data, including Biological Oxygen Demand (BOD), Dissolved Oxygen (DO), pH, nitrate, and phosphate, with social data obtained from respondents in previous studies, such as domestic waste disposal behavior, river water utilization, and community participation in environmental management (Sipahutar et al., 2025). Respondents in previous studies generally consisted of riparian communities, household groups, women communities, farmers, and local environmental organizations directly interacting with the Brantas River. Therefore, this study provides a more comprehensive, adaptive, and socio-ecological systems-based approach to Brantas River management compared to previous studies that tended to separate ecological and social aspects (Bourceret et al., 2022).

The novelty of the revised manuscript lies in the synthesis and operationalization of an integrative framework. This study does not claim that microplastics, heavy metals, community participation, or water-quality degradation are newly discovered phenomena in the Brantas River. These findings have already been documented in previous studies. The contribution of the present research is to bring these previously separated findings together within a socio-bioeconomic structure that links environmental pressure, ecological response, economic use, social behavior, and governance.

This clarification is important for strengthening the academic position of the SLR. A literature review should not reproduce previous studies as though their findings were primary observations generated by the current research. Its contribution lies in identifying patterns, relationships, gaps, contradictions, and implications across studies. In this case, the cross-study evidence indicates that ecological pressures in the Brantas River are associated with multiple human activities, vary across space and seasons, affect aquatic organisms and communities, and require governance mechanisms capable of integrating information and participation.

3.8 Contribution of the two new 2026 studies, limitations, and future research

The two 2026 studies added in this revision strengthen the manuscript in different but complementary ways. Evidence on microplastics broadens the pollutant profile by examining their relationship with water-quality parameters from upstream to downstream (Rina et al., 2026). The biological component is further strengthened through the examination of Pb and Cd exposure using physiological and histopathological responses in *Oreochromis niloticus* (Islamy et al., 2025). Together, these studies broaden the evidence base beyond the conventional water-quality studies that have traditionally dominated the literature.

More importantly, these two studies demonstrate the value of the proposed integrative framework. The microplastic study links an emerging contaminant to environmental conditions, whereas the biomonitoring study connects contamination with biological responses in organisms. When considered alongside the existing literature on BOD, nutrients, community behavior, and governance, these studies contribute to a more complete chain of evidence, extending from environmental pressure to ecological response and management implications. The present SLR does not combine the numerical datasets from these individual studies; instead, it treats them as complementary evidence within the analytical framework.

Furthermore, the evidence synthesized in this study remains subject to the limitations of the available literature. The reviewed studies differ in their sampling locations, seasons,

indicators, and analytical methods. Social studies also differ in terms of respondent groups and research questions. These differences make direct comparison difficult. Therefore, the present study applies a thematic synthesis rather than claiming a pooled statistical effect across all variables.

A further limitation is that the SLR relies on secondary evidence and therefore cannot independently verify conditions in the field. The review can identify patterns reported in previous studies, but it cannot establish the current environmental condition at every point along the Brantas River. Future research should therefore combine the framework developed here with primary monitoring data. A longitudinal dataset covering water quality, emerging contaminants, biological responses, economic activities, and social behavior would provide a stronger basis for testing the relationships proposed within the framework.

Future research could also develop a quantitative bioeconomic model. Such a model could estimate relationships between economic activities and pollution pressures, identify environmental thresholds, and compare alternative management scenarios. Social variables could be incorporated through indicators of participation, environmental awareness, compliance, and institutional capacity. The broader objective would be to move beyond evidence synthesis toward scenario analysis that can examine how alternative management strategies may affect both economic benefits and ecological outcomes.

4. Conclusions

The findings of this study indicate that the sustainability of Brantas River management is influenced by the interrelationship among community socio-economic activities, the ecological capacity of the river, and environmental governance systems. In addition, agricultural activities involving the intensive use of fertilizers and pesticides contribute to increased nitrate and phosphate concentrations in the river flow. These conditions are reflected in the increasing levels of pollutant parameters such as Biological Oxygen Demand (BOD), nitrate, phosphate, and biological contamination at several points within the Brantas Watershed. In contrast, areas with more active community involvement in waste management, riverbank conservation, and water quality monitoring demonstrate relatively better ecological conditions. These findings indicate that community social behavior has a direct relationship with changes in the ecological quality of the Brantas River within the framework of Social Ecological Systems (SES). Therefore, Brantas River management requires a bioeconomic approach that is not only oriented toward technical pollution control but also toward strengthening environmental awareness, encouraging changes in community social behavior, and developing adaptive and sustainable collaborative governance.

Community participation in maintaining river cleanliness, managing domestic waste, and conducting community-based water quality monitoring has become an important factor in strengthening the socio-ecological resilience of the Brantas Watershed. Thus, this study contributes to the development of an integrative bioeconomic approach that connects biophysical indicators, community economic activities, and social variables within a single analytical framework for sustainable river management. The integration of social and biophysical data into policy-making processes is important to ensure that river management becomes more responsive to local conditions and environmental changes. Local governments need to strengthen domestic waste management policies, improve water quality monitoring, and develop community-based environmental education programs in the Brantas Watershed area. Governments should also promote participatory and community-based water quality monitoring systems to improve the effectiveness of river management. Communities are expected to enhance environmental awareness by reducing domestic waste disposal into rivers, improving household waste management, and actively participating in environmental conservation activities. Environmental managers and local communities also need to develop regular water quality monitoring programs and

strengthen collaboration among communities, academics, and government institutions in managing the Brantas River.

This study still has limitations because it relies on a literature review approach and secondary data, which may not fully represent actual empirical conditions in the field. Therefore, future studies are recommended to develop quantitative bioeconomic models, conduct analyses based on primary data, and evaluate the effectiveness of adaptive governance in various watersheds in Indonesia. Future research is expected to produce more comprehensive, adaptive, and sustainable water resource management models. With more operational and actor-based recommendations, Brantas River management is expected to be implemented more integratively through collaboration among governments, communities, and environmental managers.

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Author Contribution

Conceptualization, A.H.S.; methodology, A.H.S.; formal analysis, A.H.S.; investigation, A.H.S.; data curation, A.H.S.; writing-original draft preparation, A.H.S.; writing-review and editing, A.H.S.; visualization, A.H.S.; supervision, A.H.S.; project administration, A.H.S. Author has read and agreed to the published version of the manuscript.

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During the preparation of this work, the author used Grammarly to assist in improving grammar, clarity, and academic tone of the manuscript. After using this tool, the author reviewed and edited the content as needed and took full responsibility for the content of the publication.

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References

- Aggarwal, R. M., & Anderies, J. M. (2023). Understanding how governance emerges in social-ecological systems: Insights from archetype analysis. *Ecology and Society*, 28(2), 25–26. <https://doi.org/10.5751/ES-14061-280202>
- Ali, M., Wulandari, S. R., & Ferdiansyah, A. (2024). Keanekaragaman dan kelimpahan vegetasi riparian di sungai Saroka Kecamatan Saronggi Kabupaten Sumenep. *Jurnal Ilmiah Biosaintropis (Bioscience-Tropic)*, 9(2), 123–135. <https://doi.org/10.33474/e-ibst.v9i2.563>
- Aranceta-Garza, F., Ramírez-Luna, S., & Seijo, J. C. (2025). Bioeconomics of a regime shift by invasive epibiont species affecting a bivalve small-scale fishery. *ICES Journal of Marine Science*, 82(1), 1–13. <https://doi.org/10.1093/icesjms/fsaf004>
- Ba, Y., & Galik, C. S. (2022). Historical manufacturing volatility and local sustainability efforts: A link to the past. *Global Environmental Change*, 72, 102421. <https://doi.org/10.1016/j.gloenvcha.2021.102421>
- Barbier, E. B. (2022). The policy implications of the dasgupta review: Land use change and biodiversity: invited paper for the special issue on “the economics of biodiversity: building on the dasgupta review” in environmental and resource economics. *Environmental and Resource Economics*, 83(4), 911–935. <https://doi.org/10.1007/s10640-022-00658-1>
- Bourceret, A., Amblard, L., & Mathias, J. D. (2022). Adapting the governance of social-ecological systems to behavioural dynamics: An agent-based model for water quality management using the theory of planned behaviour. *Ecological Economics*, 194. <https://doi.org/10.1016/j.ecolecon.2021.107338>
- Budirahayu, T., Susanti, E., & Kuntari, S. (2024). Women’s awareness of river water quality and their vulnerability to use of Brantas River. *Jurnal Sosiologi Dialekti*, 19(1), 51–65. <https://dx.doi.org/10.20473/jsd.v19i12024.51-65>
- Cahyani, W., & Irawanto, R. (2022). Pemantauan kualitas air dan keanekaragaman jenis vegetasi di bagian hulu sungai brantas Jawa Timur. *Prosiding SNPBS (Seminar Nasional Pendidikan Biologi dan Saintek)*, 299–307. <https://proceedings.ums.ac.id/snpbs/article/view/1772>
- de Souza, F. C., & Cândido, G. A. (2024). Socio-ecological resilience in water systems: a literature review. *Revista Brasileira de Ciencias Ambientais*, 59(1), 1–10. <https://doi.org/10.5327/Z2176-94782015>
- Estoque, R. C., Wu, J., & Verburg, P. H. (2026). Land system science for global environmental change and sustainability: Advances, challenges, and future directions. *Geography and Sustainability*, 7, 100415. <https://doi.org/10.1016/j.geosus.2026.100415>
- Fitriyah, I. J., Habiddin, H., Saputro, S., & Erlangga, S. Y. (2026). Seasonal water quality assessment and GIS - based pollution mapping of the Brantas River toward sustainable water management and SDG 6. *Discover Environment*, 4, 513. <https://doi.org/10.1007/s44274-026-01064-w>
- Gholizadeh, H., Zoghipour, M. H., Torshizi, M., Nazari, M. R., & Moradkhani, N. (2021). Gone with the wind: Impact of soil-dust storms on farm income. *Ecological Economics*, 188. <https://doi.org/10.1016/j.ecolecon.2021.107133>
- Gowsikraja, P. (2025). View of socio-ecological perspectives on sustainable fisheries and aquatic resource management. *Journal of Aquatic Ecology and Environmental Sust*, 2(2), 36–43. <https://fsrap.com/index.php/JAEES/article/view/154/149>
- Hariwati, L. S., Efani, A., Wardana, F. C., Fathur, M., & Hasan, R. (2026). Impacts of land use / land cover changes on water quality in the upper brantas watershed: A spatio-Temporal Analysis Using Riparian Buffer Approach. *Global Journal of Environmental Science and Management (GJESM)*, 21(2), 299–316. <https://doi.org/10.22034/gjesm.2025.02.12>

- Holmes, R., McFarlane, K., Challies, E., MacNeil, C., & Arnold, J. (2025). The social–ecological fabric of freshwater fish management: Accounting for feedback loops in human–fish interactions. *Ecosphere*, 16(4), 1–16. <https://doi.org/10.1002/ecs2.70249>
- Irawanto, R., M Afifudin, A. F., Aurina Putri, A., Wulan Cahyani, N., Nurshafa Rahmania, F., Soemarno, Setyo Leksono, A., Yanuwadi, B., Retnaningdyah, C., Riniwati, H., & Sugiyanto. (2024). Water quality analysis and water pollution effect from upstream to downstream of brantas river - east java. *Jurnal Pembangunan dan Alam Lestari*, 15(1), 24–30. <https://doi.org/10.21776/ub.jp.al.2024.015.01.04>
- Islamy, R. A., Hasan, V., Kamarudin, A. S., Mamat, N. B., Valen, F. S., & Mutmainnah, N. (2025). Biomonitoring of heavy metal pollution in the Brantas River using genotoxic and histopathological biomarkers in wild cyprinidae. *Journal of Ecological Engineering*, 26(12), 1–11. <https://doi.org/10.12911/22998993/206050>
- Kisam, A. R., & Yustiana, Y. (2025). Analysis of characteristics, bioeconomics, and optimization of sustainable management of largehead hairtail (*Trichiurus lepturus*) commodities in coastal waters of pangandaran regency. *3BIO: Journal of Biological Science, Technology and Management*, 7(2), 361–370. <https://doi.org/10.5614/3bio.2025.7.2.4>
- Kurniawan, A., Dhea, L. A., Ulfa, S. M., Yanuar, A. T., & Zamzami, M. Al. (2025). Assessment of water quality in the upper Brantas River through microplastic-associated biofilms and heavy metal accumulation Assessment of water quality in the upper Brantas River. *International Journal of Environmental Studies*, 82(4), 1707–1729. <https://doi.org/10.1080/00207233.2025.2516390>
- Mahira, S., Jatmiko, Y. D., & Koentjoro, M. P. (2026). Phenotypic and genotypic characterization of tetracycline-resistant bacteria isolated from Brantas River, Malang Raya and their biofilm formation ability. *Journal of Tropical Life Science*, 16(1), 195–206. <https://doi.org/10.11594/jtls.16.01.14.S>
- Nugroho, S. (2025). Operationalizing social-ecological system-based fishery management employing a system dynamics model: Lessons from eel fishery. *Ecological Modelling*, 509(July), 111276. <https://doi.org/10.1016/j.ecolmodel.2025.111276>
- Pahl-Wostl, C., & Knieper, C. (2023). Pathways towards improved water governance: The role of polycentric governance systems and vertical and horizontal coordination. *Environmental Science and Policy*, 144, 151–161. <https://doi.org/10.1016/j.envsci.2023.03.011>
- Pahl-Wostl, C., Knieper, C., Lukat, E., Meergans, F., Schoderer, M., Schütze, N., Schweigatz, D., Dombrowsky, I., Lenschow, A., Stein, U., Thiel, A., Tröltzsch, J., & Vidaurre, R. (2020). Enhancing the capacity of water governance to deal with complex management challenges: A framework of analysis. *Environmental Science and Policy*, 107, 23–35. <https://doi.org/10.1016/j.envsci.2020.02.011>
- Pambudi, A. S., Junaidi, R., Pramujio, B., Perencanaan, B., Nasional, P., Rasuna, J. H. R., & Jakarta, S. (2023). Conservation strategies for reducing erosion in the upper brantas watershed, Jawa Timur. *Jurnal Kebijakan Pembangunan Daerah (JKPD)*, 7(2), 121–139. <https://doi.org/10.56945/jkpd.v7i2.257>
- Pascucci, S. (2025). Theorizing polycentric governance of global socio-ecological challenges through a meso-institutional perspective. *Journal of Institutional Economics*, 21, 1–18. <https://doi.org/10.1017/S1744137425100325>
- Purwanto, Franklin, E. C., White, A., & Mardiani, S. R. (2023). Multiple-goal bioeconomic programming to address conflicting management objectives in Indonesian small pelagic fisheries. *Marine Policy*, 150, 105519. <https://doi.org/10.1016/j.marpol.2023.105519>
- Ramcilovic-Suominen, S. (2023). Envisioning just transformations in and beyond the EU bioeconomy: inspirations from decolonial environmental justice and degrowth. *Sustainability Science*, 18(2), 707–722. <https://doi.org/10.1007/s11625-022-01091-5>
- Rifai, R. M., Ameril, C., Mukhid, B., & Ramadani, F. (2026). Growth-response variation among selected coliform isolates under antibiotic stress in the Brantas River, East Java, Indonesia. *Biodiversitas Journal of Biological Diversity*, 27(6).

- <https://doi.org/10.13057/biodiv/d270615>.
- Rina, R., Soegianto, A., Eko, F., Rahma, C., Dwyta, A., Indradewi, N., Prasetyo, E., & Melissa, C. (2026). Chemosphere the spatial distribution of microplastics in correlation with water quality parameters from the upstream to the downstream of the longest river in East Java, Indonesia. *Chemosphere*, 409, 144998. <https://doi.org/10.1016/j.chemosphere.2026.144998>
- Rizky, R., & Rahayu, M. I. F. (2025). Efektivitas pengawasan pemerintah daerah terhadap kualitas air sungai: Studi kasus pencemaran sungai Brantas Jawa Timur. *USRAH: Jurnal Hukum Keluarga Islam*, 6(2), 227–236. <https://doi.org/10.46773/usrah.v6i2.2123>
- Sidjabat, F. N., Alwi, V., & Puspitasari, Y. (2020). Measuring of lead in river water and local bioindicators in Brantas River Kediri City, East Java Province. *Jurnal Ekologi Kesehatan*, 19(3), 161-173. <https://doi.org/10.22435/jek.v19i3.3459>
- Sipahutar, L., Tri Budi Prayogo, & Emma Yuliani. (2025). Investigasi tingkat pencemaran daerah aliran sungai brantas akibat aktivitas agrikultur serta perubahan musim di Indonesia. *Jurnal Teknologi Dan Rekayasa Sumber Daya Air*, 5(1), 402–412. <https://doi.org/10.21776/ub.jtresda.2025.005.01.039>
- Sulistiyowati, E., & Uyun, S. (2022). The evaluation of a website for participatory water quality monitoring of rivers in Indonesia. *Proceedings of the International Conference on Science and Engineering (ICSE-UIN-SUKA 2021)*, 211, 112–115. <https://doi.org/10.2991/aer.k.211222.018>
- World Meteorological Organization. (2021). *Weather-related disasters increase over past 50 years, causing more damage but fewer deaths-World Meteorological Organization*. World Meteorological Organization (WMO).

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